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PHYTOTOXICITY OF DDT DUSTS AND SPRAYS TO TRUCK CROPS IN WISCONSIN

Preliminary Observations

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During the summers of 1944, 1945, and 1946 experiments were conducted at two truck farms on the outskirts of Madison, Wis., to determine whether DDT dust mixtures, and in one year sprays, had any deleterious effect on the foliage or fruit of the common truck crops grown in that area. The effect of DDT residues in the soil, was not studied in these experiments, and no attempt was made to determine the effect of DDT on the yield of plants. The crops were grown under commercial conditions in fertile, well-drained Miami silt loam soil.

In reporting on the toxicity of DDT many authors have noted briefly its effect on the host plants, and a few experiments have been conducted in different parts of the country primarily to determine the tolerance of plants to DDT. Young (6) tested a 50-percent DDT dust mixture on 17 species of plants under field conditions, including cowpea and tomato, and no foliage injury was observed. Bottger and Levin (1) reported no injury from DDT sprays (8 lb. per 100 gal.) to the foliage of pumpkin, squash, bean, collard, potato, and tomato.

The New Jersey Agricultural Experiment Station (4) reported injury by DDT to squash, cantaloup, cucumber, snap bean, and tomato. White (5), in summarizing the results of field experiments with DDT in several States, reported injury under some conditions to squash, cucumber, and pumpkin, and listed 26 truck crops, including snap bean, tomato, and cantaloup on which no injury had been observed. A dust containing at least 5 percent of DDT was applied to each of these crops. Bruce and Tauber (2) reported experiments in which 3-percent DDT dust injured Acorn squash and muskmelon, but did not

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cause foliage injury to potato, cabbage, Hubbard squash, or Buttercup squash. Hervey and Schroeder (3) reported a decided difference in the susceptibility of the foliage among cucumber varieties to injury from DDT. In general these reports indicated a high tolerance to DDT of most truck crops, except cucurbits.

A classification of all the truck crops included in these experiments is presented in table 1.

Table 1.—Vegetables treated with DDT in phytotoxicity experiment. Madison, Wis., 1944-46.

Common name	Scientific name	Horticultural varieties	Number of tests
Legume family:			
Canning pea, sweet type	<u>Pisum sativum</u>	Perfection	3
Bush snap bean, green pod and wax pod	<u>Phaseolus vulgaris</u>	Black Valentine, Tendergreen, Stringless Green Pod, Golden Bountiful Wax	7
Bush lima bean	<u>Phaseolus lunatus</u> , var. <u>macrocarpus</u>	Baby Potato, Improved Bush	4
Mustard family:			
Cabbage, common and red	<u>Brassica oleracea</u> , var. <u>capitata</u>	Danish Ballhead, Wisconsin Hollander No. 8, Penn. State Ballhead, Peerless, Globe Red, Red Weathersfield	9
Broccoli	<u>Brassica oleracea</u> , var. <u>botrytis</u>	Italian Green Sprouting (Calabrese)	6
Cauliflower	do.	Aberlee Special, Forbes	6
Chinese cabbage	<u>Brassica pekinensis</u>	Narrow Head	2
Radish	<u>Raphanus sativus</u>	Crimson Globe	1
Turnip	<u>Brassica rapa</u>	Purple Top White Globe	2
Kohlrabi	<u>Brassica caulorapa</u>	Early White Vienna	1
Potato family:			
Eggplant	<u>Solanum melongena</u> , var. <u>esculentum</u>	Black Beauty	7
Potato	<u>Solanum tuberosum</u>	Early Ohio, Carman, mixed varieties	4
Tomato	<u>Lycopersicon esculentum</u> , var. <u>vulgare</u>	Bonny Best, Valiant, Marglobe, Stokesdale	7
Sweet pepper	<u>Capsicum frutescens</u> , var. <u>grossum</u>	California Wonder, Pimento, Neapolitan	6
Goosefoot family:			
Table beet	<u>Beta vulgaris</u>	Early Wonder	3
Swiss chard	<u>Beta vulgaris</u> , var. <u>cicla</u>	Lucullus	2

Table 1.--Continued.

Common name	Scientific name	Horticultural varieties	Number of tests
Lily family:			
Onion	<u>Allium cepa</u>	Yellow Globe Danvers, Espanolia, mixed varieties	4
Asparagus	<u>Asparagus officinalis</u>	Variety unknown	1
Buckwheat family:			
Rhubarb	<u>Rheum rhabonticum</u>	Variety unknown	2
Composite family:			
Leaf lettuce	<u>Lactuca sativa</u> , var. <u>crispa</u>	Grand Rapids	1
Parsley family:			
Carrot	<u>Daucus carota</u> , var. <u>sativa</u>	Chantenay	3
Parsley	<u>Petroselinum hortense</u>	Double Curled	2
Dill	<u>Anethum graveolens</u>	Mammoth	3
Paranip	<u>Pastinaca sativa</u>	Hollow Crown	2
Gourd family:			
Squash, bush type	<u>Cucurbita pepo</u>	Straightneck Summer, Crookneck Summer	4
Squash, vine type	<u>Cucurbita maxima</u>	Table Queen (Acorn), Buttercup, Warted Hubbard	12
Pumpkin	<u>Cucurbita pepo</u>	Kentucky Field, Small Sugar	2
Cucumber	<u>Cucumis sativus</u>	A 500, Cubit, mixed varieties	6
Muskmelon	<u>Cucumis melo</u>	Milwaukee Market	1
Watermelon	<u>Citrullus vulgaris</u>	Kleckley's Sweet	1

A total of 9 families, embracing 26 species, with additional varieties within a species and 56 or more horticultural or named varieties, were included in the 3-year study.

Throughout the studies all dusts were applied with plunger-type hand dusters. Pyrophyllite, talc, or a mixture of both materials, was employed as a diluent for dust mixtures.

#### DDT Dusts in 1944

Since very little was known about the toxicity of DDT to the foliage of truck crops, only a few plants of each crop were included in the first tests. After these first trials the plots averaged about 1.3 percent of an acre but the size varied considerably. All crops were treated with both heavy and light applications of dust mixtures containing 10, 5, and 2.5 percent of DDT in pyrophyllite and talc. One half of each plot was given two applications one week apart whereas the other half was given only the first application.

To make the heavy application enough dust was expelled from a duster to thoroughly cover the different types of foliage with a uniform deposit. For the light application a very light, if not always uniform, deposit was made. Considerable variation in the size of the different crop plants, their distance apart in the row and between the rows, the adherence of dust to the different types of foliage, and varying (although low) wind velocities resulted in a wide range in the rate of application, when figured on an acre basis. The rate of the heavy application averaged about 35 pounds per acre and the light application, 10 pounds per acre.

In 1944 the two applications at the two farms were made a week apart between June 28 and July 10. No maximum temperature of 90° F. or above occurred before August 2. One rain amounting to 0.79 inch fell 3 days after the second application at one farm, while another rain totaling 1.03 inches fell the day following the second application at the other farm. Three additional rains from July 23 to 27 totaled 1.60 inches.

Of 18 horticultural varieties of crops treated, the only injury observed was on the foliage of 4 kinds of cucurbits--cucumber (mixed varieties), and Crookneck Summer, Straightneck Summer, and Table Queen (Acorn) squash. This injury was evident following the heavy application of all three strengths of DDT and following light application of the 10- and 5-percent strengths. Occasional slight injury could be found where a light application of the 2.5-percent DDT had been made.



On cucumber a chlorosis and mosaic effect appeared on most of the treated plants and persisted for weeks. These symptoms were confined to the dusted foliage and new growth was not affected. Because of the effective control of the striped cucumber beetle (Diabrotica vittata (F.)) with DDT and the consequent reduction in the amount of bacterial wilt occurring on treated plants, it was difficult to determine whether the foliage injury caused by DDT resulted in stunting the plants.

The Crookneck and Straightneck squash revealed a chlorosis and dwarfing of the leaves following both applications. New growth was not affected, but slight stunting of the plants probably resulted, especially from the heavy rate of application, because after a month, even though all the plants were intergrown, the dusted ones did not appear quite so luxuriant as those not dusted.

Table Queen squash was treated at both farms, and was more severely injured than the other cucurbits. A general chlorosis and mosaic effect became conspicuous following both applications. Although new growth did not show these symptoms, the plants (particularly at one farm) were stunted, as evidenced by the reduced size of leaves and length of runners.

#### DDT Dusts in 1945

The 1945 experiment was planned to test only a dust mixture containing 5 percent of DDT, 45 of pyrophyllite and 50 of talc applied to larger areas than had been treated the previous year, and to regulate the rate of application so that a uniform, medium coverage would be obtained. Two applications, 8 or 9 days apart, were made, using an average rate of 13 pounds of this dust mixture per acre. Crops were not nearly so far advanced in 1945 as they had been in 1944, and therefore required less dust in 1945 to obtain a uniform coverage. The area of each crop dusted at each application averaged 1,000 square feet, or 2.3 percent of an acre.

The two applications were made between July 9 and 19. Two rains totaling 0.62 inch fell during this period, and another of 0.54 inch 2 days after the applications were completed. There were three additional showers totaling 0.98 inch during the last 4 days of the month, and nine rains totaling 3.94 inches during August, over half of it falling in the first 2 weeks. Maximum temperatures of 90° to 96° F. occurred on 5 days between July 19 and 31.

Of 30 horticultural varieties of crops dusted, the only injury that occurred was on the foliage of 5 kinds of cucurbits--cucumber (A 500 and mixed varieties), and Table Queen, Warty Hubbard, Buttercup, and Straightneck Summer squash. Pumpkin was uninjured.

On cucumber, treated at both farms, a slight chlorosis and mosaic effect was evident on most of the dusted leaves 8 days after the second application, and treated plants were not quite so advanced as the untreated ones. A month later, however, both treated and untreated plants appeared to be equally large and healthy. At one farm a few of the untreated plants exhibited, in slight degree, the chlorosis and mosaic effect observed on treated plants, but the amount on the untreated plants was less than on the treated ones.

Table Queen squash, also treated at both farms, revealed no injury due to DDT at one farm. At the other farm, however, a slight chlorosis was evident on a few treated leaves a week after the second application, and although persisting for weeks it was not sufficient to be considered damaging to the crop.

A week after the second application slight chlorosis was observed occasionally on Warted Hubbard, Buttercup, and Straightneck squash. This condition lasted for 2 weeks, but was not considered severe enough to be of any concern. Injury to squash was not so pronounced in 1945 as it had been in 1944.

#### DDT Dusts in 1946

In 1946 dusting with DDT was continued. Two mixtures containing 5 percent of DDT were employed. In the first, DDT was ground in a diluent, as was done in the two previous years, and in the second, the DDT was dissolved in a volatile solvent before being added to the diluent. To make the latter mixture 3 pounds of technical DDT was dissolved in  $2\frac{1}{2}$  quarts of acetone, and the solution was then sprayed, one quarter at a time, into 57 pounds of talc in a revolving mixing machine containing stones. Ten minutes was allowed for mixing each aliquot so that most of the acetone would evaporate. After all the solution had been introduced, the batch was mixed for one-half hour, at the end of which time practically all the acetone had evaporated.

Again, as in 1945, two applications were made, each designed to give a uniform coverage at a medium rate. The rate of application averaged 31 pounds per acre, although because of the difference in the stage of crop growth, it averaged nearly twice as much at one farm as at the other. The area of each crop treated averaged 436 square feet, or 1 percent of an acre.

The two applications with each dust mixture were made on July 15 and 26. Maximum temperatures of  $90^{\circ}$  to  $96^{\circ}$  F. occurred on 8 days between July 18 and August 16. Rain in the amount of

0.07 inch fell 2 days after the first application, while three showers totaling only 0.30 inch fell in the week following the second application. Except for one storm with 1.04 inches of rain on August 9, there was little rain during the month.

Twenty-seven horticultural varieties of crops were treated, including eight kinds of cucurbits. Cucumber, Table Queen and Buttercup squash were treated at both farms, and Straightneck Summer and Warty Hubbard squash, pumpkin, watermelon, and muskmelon were treated at one farm or the other.

The only foliage injury which could be attributed to DDT occurred on Table Queen squash at one farm, where a bronzing with some chlorosis on dusted leaves was evident following both applications with each dust mixture. New foliage produced subsequent to application was not affected, and the plants were not stunted.

There was a possibility of slight DDT injury to the foliage of cucumber and watermelon at one farm, but inasmuch as both crops suffered from drought and exhibited some yellowing and chlorosis on both treated and untreated portions of the planting, no injury could be laid to DDT. In fact, most of the cucurbits at both farms suffered from drought and wilted from time to time. Some were attacked by foliage disease with consequent spotting and yellowing of the leaves. In 1946, then, no injury attributable to the use of either formulation of DDT occurred, except on Table Queen squash at one farm.

During the three summer seasons no injury from DDT appeared on the fruit of any crop.

#### DDT Spray in 1945

Toward the latter part of the season a single application of two spray mixtures was made. An emulsion spray was prepared by mixing technical DDT 0.2 percent, xylene 0.35 percent, and a phthalic glyceryl alkyl resin (Triton B-1956) 0.025 percent in water. <sup>3/</sup> A suspension spray, made from a proprietary preparation containing DDT, spreading, wetting, and suspension agents, plus a diluent, was diluted with water to contain 0.2 percent of DDT. The sprays were applied by means of a knapsack sprayer operated at a pressure of 75 pounds per square inch at an average rate of 35 gallons per acre.

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<sup>3/</sup>The water used in all sprays was from the city of Madison water supply. It contained 8.8 p. p. m. of chloride, and its hardness rating was 19.7 grains per gallon.



Cucumber, Table Queen squash, cabbage, broccoli, bush lima bean, eggplant, tomato, bush snap bean, cauliflower, sweet pepper, and onion were treated. All 11 crops were sprayed with the suspension, but only the first 4 were treated with both sprays.

On several varieties of cucumber marked injury from the emulsion was evident, 3 weeks after application, as a yellowing of the treated foliage and a stunting of the plants. Slight injury to cucumber from the suspension was revealed as a chlorosis at the tips and margins of the leaves.

No injury was observed on the other crops from either spray.

#### Summary

During the summers of 1944, 1945, and 1946, DDT dust mixtures and, in one experiment, DDT sprays were applied to 56 or more horticultural varieties of truck crops in small field plots by means of hand dusters and sprayers.

Definite foliage injury occurred on several varieties of cucumber and the following varieties of squash: Crookneck summer, Straight-neck summer, Table Queen (Acorn), Buttercup, and Warty Hubbard. No injury traceable to the application of DDT could be discerned on any other crop.

Results of the experiment did not indicate that high temperatures contributed to DDT foliage injury. Rain, on the other hand, appeared to be associated with injury from DDT. The greatest amount of injury was recorded in the year having the highest rainfall during or closely following the applications, while only slight injury, to one crop, occurred in the year having a very light rainfall during or closely following applications.

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